U. S. Department of Energy • Federal Energy Technology Center

Environmental Solutions

A Periodic Newsletter for FETC Stakeholders

Volume 1 Issue 1

Welcome

to the *Environmental Solutions* newsletter.

This is the first issue of a periodic newsletter from FETC, the Federal Energy Technology Center. In it we hope to convey information about solutions to the environmental problems that threaten our nation's natural resources and public health. As part of our mission to solve national energy and environmental problems, we partner with stakeholders to develop low-cost, technical solutions to the problems facing our air, water, and soil. The goal of this work is to transfer advanced, environmentally superior technologies to industry so that all may benefit.

As one of the largest fossil-energy research organizations in the world, FETC is well suited to address the energy and environmental challenges of the 21st century. Through our predecessor research laboratories—and in collaboration with industry, academia, private parties, and local, state, tribal, and federal agencies—we have a long history of successfully integrating energy and environmental solutions. Working together, we have helped develop technical solutions that combine ecological, socio-economic, and institutional perspectives.

We invite comments and suggestions about the *Environmental Solutions* newsletter that will make it more useful to you. We also welcome questions about FETC and any of our research programs. Please note that each article ends with a point of contact that you can use to obtain more information about a specific product or initiative.

We are proud of the progress being made—*together with our research partners*—to provide environmental solutions that will benefit our nation now and for years to come. Please share with us, and read each issue of *Environmental Solutions*.

Environmental Solutions is a periodic newsletter of the U. S. Department of Energy, Federal Energy Technology Center (FETC) that communicates information about FETC's environmental mission, programs, and current issues.

For further information about FETC, requests for copies of this newsletter, or suggestions for articles, please contact the senior editor, Heather Quedenfeld, at hquede@fetc.doe.gov.

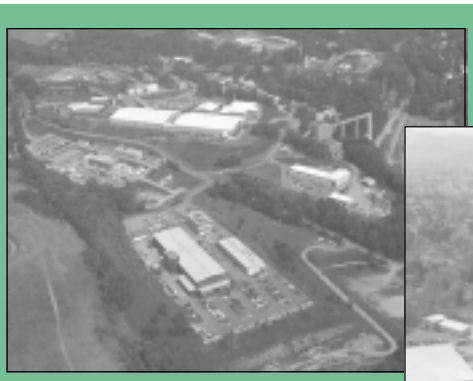
Federal Energy Technology Center

626 Cochrans Mill Road
P.O. Box 10940
Pittsburgh, PA 15236-0940

3610 Collins Ferry Road
P. O. Box 880
Morgantown, WV 26507-0880

1-800-553-7681

www.fetc.doe.gov



Federal Energy Technology Center, Pittsburgh, Pennsylvania

Federal Energy Technology Center, Morgantown, West Virginia

Watershed Partnerships

The U.S. Environmental Protection Agency (EPA) estimates that at least a third of our nation's rivers, half of its estuaries, and half of its lakes are not safe for uses such as swimming and fishing. In the 25 years since passage of the Clean Water Act, we have made tremendous advances controlling pollution from point sources associated with industries and municipalities, but we have not done enough to assess and control nonpoint source pollution. This kind of pollution results from activities such as agriculture, forestry, mining, grazing, and construction that physically disturb the land or water. It occurs when water runs over land or underground, picking up pollutants and depositing them into rivers, lakes, or coastal waters, or into groundwater. Today, nonpoint source pollution is the largest source of water quality problems in the United States.

FETC is involved in a number of wide-ranging initiatives to address the diverse problems facing our nation's water resources. Recognizing that new problems require a new approach to finding solutions, these initiatives are underpinned by the "watershed partnership" approach. Watershed partnership is a cooperative, community-based approach to protecting entire watersheds. Cooperation is key. Watersheds cannot be restored or protected unless all parties—citizen action groups; industry; state, tribal, federal and local governments; and the general public—work together to identify problems and implement solutions.

The watershed approach is supported by unified watershed assessments, watershed restoration action strategies, and watershed management plans. In partnership with regional stakeholders, FETC applies its technical capabilities to (1) ensure effective regional and national integration of legal, regulatory, technical, and socioeconomic water resource issues; (2) supplement diminishing federal and state capacity for planning, monitoring, and protecting water resources; (3) develop and promote more effective and representative integrated watershed models; and (4) provide real-time access to comprehensive watershed data and information.

As an example of how this can work, in September 1997, the County Commission of Preston County, West Virginia, asked FETC to help design a county-wide watershed improvement program. After holding public meetings and reviewing available funding sources, the county submitted an application for an AmeriCorps grant to the West Virginia Commission for National and Community Service. FETC was one of some 20 regional governmental, industry, and community organizations that came together in a consortium to design and commit resources to the program. In July 1998, AmeriCorps awarded the county a $147,000 per year renewable grant that will be matched by $35,000 in county funds and $60,000 in partner commitments. Twenty AmeriCorps volunteers will lead community groups in building wetlands, monitoring and removing litter from streams, planting trees, and raising the community's knowledge of the challenges to their watersheds.

These are the hallmarks of the watershed approach: solving community-identified problems, building stakeholder partnerships, taking a holistic view of an entire watershed. In future issues of this newsletter we will bring you more specific information about individual initiatives that solve water problems. All of them share a common approach and the same goal: ensuring dependable sources of pure, life-sustaining water.

For more information, contact Jan Wachter at jwacht@fetc.doe.gov.

BOA: The Asbestos-Removing Robot

Although robots can conjure up images of science fiction androids—C3PO of Star Wars, for example, or Star Trek's Data—the work being done by researchers at Carnegie Mellon University's Robotics Institute isn't science fiction at all. In a project funded and managed by FETC, they have developed a 4-foot-long, 135-pound asbestos-removing robot called BOA (short for Big On Asbestos), which has the potential to reduce the risk of lung diseases in workers and save money as well.

One of FETC's focus areas is the deactivation and decommissioning of the United States' nuclear weapons complex. This includes stripping miles of asbestos-covered pipe. Up until the 1970s, asbestos was used in a wide variety of products for its insulating and fire-retardant properties. Asbestos is ubiquitous—in its native form, it's found in two-thirds of the rocks in the earth's crust—and intact, it poses no threat. But when it's disturbed, as it is during removal, tiny asbestos fibers can become airborne and be inhaled, potentially harming workers. Compounding the problem, some of the asbestos-covered pipe to be removed in the weapons complex has the added hazard of radioactive contamination.

Thus, the obvious value of a robot to remove the asbestos.

Moving along horizontal pipes at 30 feet per hour, its work area enclosed in an 18-inch-long, 16-inch-diameter cylinder, BOA's cutting tools pierce any aluminum cladding, wiring, or fabric that covers the asbestos. Water jets then cut the asbestos itself, which has a consistency like chalk, into 2 1/2-inch chunks. The asbestos chunks, water, and other debris fall to the bottom of the device, where they are sucked through a hose into devices that recycle the water for reuse by BOA and deposit the solid debris into bags for disposal. BOA is designed to accommodate 3-inch or 4-inch-diameter pipes, but could be modified for pipes up to 12 inches.

Three clamps keep BOA attached to the pipes; to move along, it moves one clamp at a time. When BOA encounters a pipe hanger, the containment cylinder is opened, and the robot moves to the other side of the hanger, leaving a chunk of asbestos that is later removed by a human worker. Even though BOA can only remove asbestos from horizontal pipes, and it leaves some insulation around pipe hangers, this can still significantly reduce human exposure to asbestos, since only about 5 percent of industrial piping is vertical. Further, since conventional asbestos removal is a slow, labor-intensive process, BOA has the potential to cut the cost of stripping asbestos from pipes by 25 to 50 percent.

BOA is not yet to the point where specific purchase orders can be taken, but the hope is that BOA will have a commercial life of its own. BOA is already generating excitement; the robot received second place in the 1997 National Engineering Design Competition sponsored by Design News magazine. BOA's design is currently being improved in preparation for large-scale demonstration projects, after which contractors bidding for DOE work may choose to include the robot in their plans.

Reducing worker risks and cutting costs—BOA isn't science fiction at all. It is a practical product producing real results.

For more information, contact Vijay Kothari at vkotha@fetc.doe.gov.

BOA at work. Ahead of BOA (left side of photo) is asbestos to be removed; behind (right side of photo) is stripped pipe. A short length of pipe to the right has not been stripped becaused of the vertical pipe hanger. This small area will need to be cleaned by a human worker.

DOE/Fossil Energy's Ambient $PM_{2.5}$ Research Program

Since passage of the 1970 Clean Air Act Amendments, the electric-utility industry has made considerable strides in reducing air emissions. Particulate emissions, for example, decreased more than 84 percent from 1970 to 1996, even as electricity generation at electric utilities increased by more than 100 percent. By 2010, however, new environmental requirements for coal-based power systems may be necessary because of concerns about human health risks, visibility impairment, harm to ecosystems, and global warming.

Particulate matter (PM) is a mixture of solid particles and liquid droplets found in the air. They range in size from particles large enough to be easily seen by the naked eye, such as soot or smoke, to particles that are so small they can only be seen with an electron microscope. Particles with an aerodynamic diameter of 2.5 micrometers or less are called "fine" particulates, or $PM_{2.5}$. By comparison, the diameter of the human hair is about 80 to 100 micrometers.

When fine particulates are emitted directly into the air they are called "primary" $PM_{2.5}$. When gaseous precursors undergo chemical reactions in the air to form fine particulates, they are called "secondary" $PM_{2.5}$. SO_2 (sulfur dioxide) and NO_x (any of the nitrogen oxide gases) are examples of gaseous precursors. SO_2 and NO_x react with ammonia in the air to form ammonium sulfate and ammonium nitrates, respectively, which are species of $PM_{2.5}$.

One of the FETC research programs addressing these concerns now is the Department of Energy (DOE)/Fossil Energy (FE) ambient $PM_{2.5}$ research program. $PM_{2.5}$, or "fine" particulates, are particles with aerodynamic diameters of 2.5 micrometers or less. Fine particulates are a special health concern because their small size allows them to penetrate the terminal bronchiole and lodge deeply in the lungs. In 1997—in response to evidence that fine particulates were contributing to respiratory symptoms and disease, decreased lung function, and premature death—the U.S. Environmental Protection Agency (EPA) revised the National Ambient Air Quality Standards (NAAQS) to address ambient air concentrations of $PM_{2.5}$.

Ambient $PM_{2.5}$ comes from a variety of emission sources, both man-made and natural. Motor vehicle exhaust, power plants, residential wood stoves and fireplaces—even forest fires and sea spray—can contribute. The combustion of coal to generate electricity produces both primary $PM_{2.5}$ (e.g., fly ash and carbon soot) and the gaseous precursors (e.g., SO_2 and NO_x) to secondary $PM_{2.5}$ (e.g., ammonium sulfates and nitrates). However, while it's clear that coal-fired boiler emissions contribute to ambient $PM_{2.5}$, the link between those emissions and the visibility and health-related impacts associated with ambient $PM_{2.5}$ is not clear.

The goal of the DOE/FE ambient $PM_{2.5}$ research program is to help determine that link. The program has three specific objectives:

- Determine the concentration and chemical and physical composition of ambient fine particulates.
- Characterize the emissions of primary $PM_{2.5}$ and the precursors to secondary $PM_{2.5}$ from coal-fired boilers.
- Develop technologies to cost-effectively control both primary $PM_{2.5}$ and the precursors to secondary $PM_{2.5}$.

These activities will provide information about emission trends, human health effects, regional haze and climate-change issues, and the effectiveness of emissions management strategies. They will also help coal-based power plants reduce emissions of fine particulates and their precursors should further reductions be necessary to address health or visibility issues.

One area of research will be ambient air monitoring. DOE/FE is working with key stakeholders to establish and operate several $PM_{2.5}$ monitoring sites. These sites will sample for an array of chemical species, including important precursor gases. They will also collect meteorological data, such as wind speed and direction, temperature, precipitation, and relative humidity. The largest activity in this research area is the Upper Ohio River Valley Project (UORVP). This effort will involve the installation and operation of multiple $PM_{2.5}$ monitoring sites in eastern Ohio, northwestern West Virginia, and western Pennsylvania (see map). Information gathered from these sites will lead to a better understanding of how different emission sources in the upper Ohio River valley contribute to downwind air quality.

In another air monitoring project, DOE/FE will collect data at $PM_{2.5}$ monitoring sites in the Great Smoky Mountains National Park in Tennessee, and in Atlanta, Georgia. This research will take place through an Interagency Agreement with the Tennessee Valley Authority (TVA). The results will help answer questions about regional haze and human exposure to fine particulates in the southeastern United States, and will

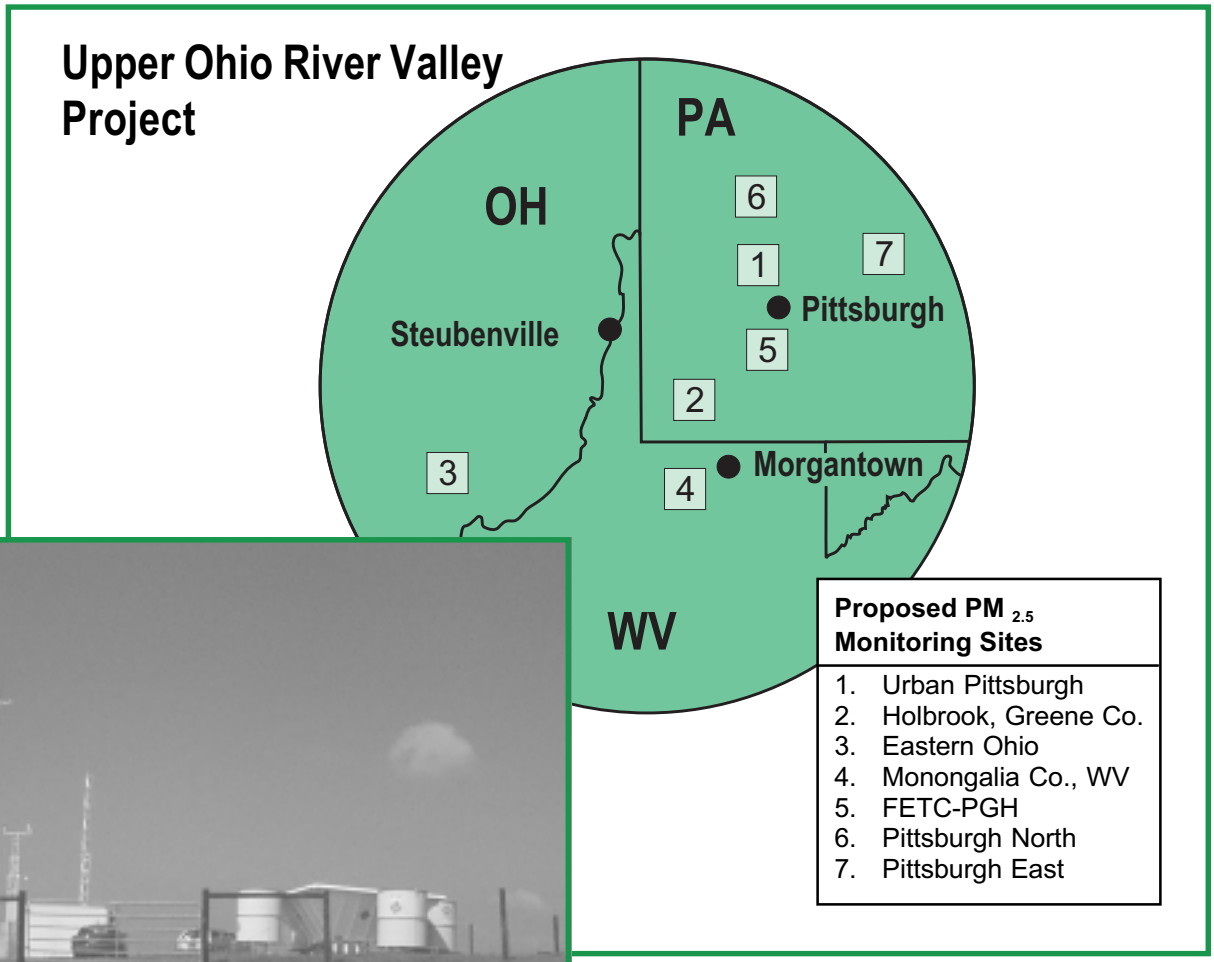
give researchers an opportunity to compare data for this region with data from the geographically and climatically distinct UORVP.

In addition to ambient air monitoring, the $PM_{2.5}$ research program will include these efforts:

- The program will continue to develop cost-effective emissions-control technologies for coal-fired utility boilers. This will include a research and development portfolio of advanced technologies for controlling both primary $PM_{2.5}$ and the precursors to secondary $PM_{2.5}$.
- Under the TVA Interagency Agreement, DOE/FE will investigate the formation and transport of secondary $PM_{2.5}$ in the plume of a large coal-fired power station. This effort will also assess how low-NOx burners and wet flue-gas desulfurization technology affect emissions of $PM_{2.5}$ precursors and their conversion to $PM_{2.5}$.
- DOE/FE will participate in a study to assess the impact of emission sources in Mexico and the United States on visibility in the Big Bend National Park in Texas.
- The $PM_{2.5}$ research program will include the characterization of primary $PM_{2.5}$ emissions in a 10 MWe pilot-scale coal facility.

The DOE/FE ambient $PM_{2.5}$ research program will help ensure that sound science is brought to bear in any future regulatory decision-making related to the potential health and environmental impacts of ambient fine particulates. It will also ensure that coal-based electric power generation remains a viable and environmentally sound component of the U.S. energy mix well into the 21st century.

For more information, contact Tom Feeley at feeley@fetc.doe.gov.



Monitoring sites such as the one pictured, near Holbrook, Greene County, PA, will sample for an array of chemical species and will collect meteorological data to give a better understanding of the link between emission sources and downwind air quality.

Making Good Use of What's Left Over

Sludge, landfills, sluice ponds. Not exactly topics of most dinner conversation. But as we dine in our climate-controlled, artificially lighted houses, we not only consume energy that generates materials found in these disposal sites, we are also surrounded by products capable of utilizing these materials. Cement, concrete, wallboard, structural fills: all can productively utilize the by-products of coal-based power generation.

Coal-burning electric utilities produce large volumes of ash and sludge. Every year, more than 100 million tons of coal combustion by-products (CCBs) are produced in the United States. Only 25 percent is put to productive use; the remainder ends up in landfills or sluice ponds, at significant cost to electric utilities (and ultimately to the consumer).

Why aren't more CCBs used productively? Part of the answer lies in how state regulatory agencies categorize CCBs. CCBs have traditionally been considered solid "wastes" by most state agencies. Though not hazardous, CCBs are still subject to stringent disposal regulations. While any use of CCBs may be approved on a case-by-case basis, the approval process can be time-consuming, discouraging both the producer and user of the material.

Some states have pre-approved some uses of CCBs: fly ash may be used as concrete admixture, bottom ash as a road base, and sludge as a feedstock for the manufacture of wallboard. While this pre-approval streamlines the process, not all states specify pre-approved uses in their regulations, and even among those that do the allowable uses vary from state to state.

FETC is working with its research partners to solve this problem and answer other questions about CCBs. The FETC CCB Utilization Research Program is finding new methods to utilize CCBs so that more "beneficial use" options can be added to the list of pre-approved uses for CCBs, thereby lowering the cost of coal-fired electric power.

An exciting aspect of the CCB Utilization Research Program is that solutions that help solve the economic problems of CCB disposal also help solve other problems at the same time. One of these is the environmental problem of acid mine drainage (AMD), which affects nearly 3,500 miles of streams in Appalachia.

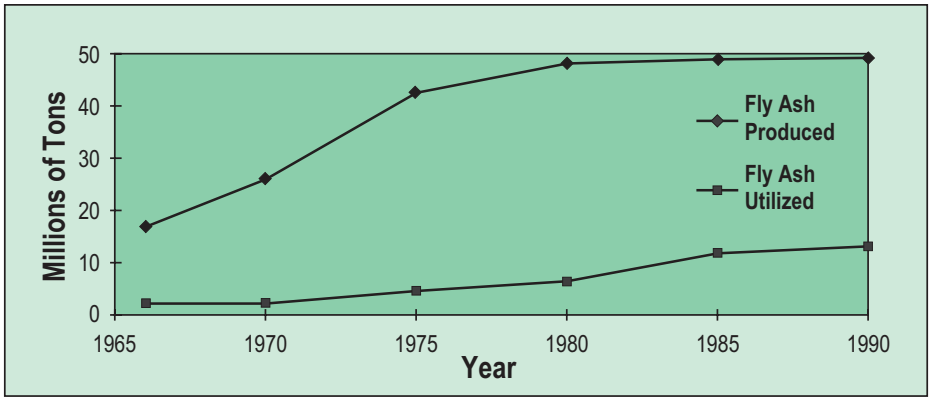
These photos illustrate an abandoned surface mine site before (left) and after (right) reclamation with fluidized-bed combustion ash.

CCBs are already being used to prevent or remediate AMD at strip mines and coal refuse sites, but much of the current AMD damage in Appalachia comes from abandoned underground coal mines. Many types of CCBs can be engineered to produce grout-like materials with very low permeabilities. By injecting large volumes of CCB grouts into abandoned underground mines so that most or all of the void spaces are filled, it may be possible to divert groundwater away from acid-forming materials in the mine.

While this solution is unlikely to stop the mine drainage completely, it may result in drainage that is much less damaging to the environment. Research has progressed from the laboratory through pilot tests to the full-scale demonstration phase, and the results look promising.

So maybe CCBs haven't made good "cocktail patter" in the past, but as work in this area continues to provide wide-ranging economic and environmental benefits, it will be the toast of the town.

For more information, contact Bill Aljoe at aljoe@fetc.doe.gov or Scott Renninger at srenni@fetc.doe.gov.



Coal combustion by-products (CCBs) are the inorganic residues that remain after pulverized coal is burned to produce electrical energy. Fly ash is the finely-divided CCB collected from flue gases. Fly ash is a very fine, powdery material consisting primarily of silica; its particles are almost totally spherical in shape. Removing the fly ash from flue gases prevents it from polluting ambient air, and provides a valuable recycled resource for industry.

Fly ash can be used to produce a variety of concrete mixes. Using fly ash in place of other typical pavement materials—lime, cement, or crushed stone—conserves energy. According to the Fly Ash Resource Center, each ton of fly ash used to replace a ton of cement saves the equivalent of nearly one barrel of imported oil. It also means that fewer greenhouse gases are produced, which would otherwise contribute to global warming.

The FETC Solid Waste Team, an in-house team of FETC researchers, is conducting a comprehensive leaching study to determine the consequences of using CCBs for mine remediation, as bulk fill, or in other applications where they could be exposed to water. The study is a column experiment in which samples of fly ash are exposed to seven standard leachants (sulfuric acid, ferric chloride, synthetic precipitation, sodium carbonate, synthetic groundwater, acetic acid, and deionized water) for 30 to 120 days.

Researchers plan to perform leaching tests on at least 50 CCB samples, including high-carbon fly ashes and the by-products from fluidized-bed combustion. Leaching tests have already been completed on 24 fly ash samples. The average amount of beryllium, cadmium, cobalt, lead, antimony, and selenium leached from CCB samples is less than 10 mg/kg. The amount of arsenic, barium, chromium, copper, nickel, or zinc released may be between 10 and 50 mg/kg, depending on the pH of the leaching solution. These amounts can generally be considered negligible, indicating that these samples may be safe to use in applications where they are exposed to precipitation or groundwater.

For more information, contact Ann Kim at akim@fetc.doe.gov.

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Federal Energy
Technology Center
3610 Collins Ferry Road
P. O. Box 880
Morgantown, WV
26507-0880

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